

Morphology Observation of Langmuir-Blodgett Thin Film based on Silsesquioxane Dendrimer

Gi-Chan Sung¹, Ji-Yoon Lee¹, Dae-Sik Shin², Chungkyun Kim², Young-Soo Kwon^{1,*}

¹Department of Electrical Engineering and NTRC, Dong-A University
840 Hadan 2-dong, Saha-gu, Busan 604-714, KOREA
Phone: +82-51-200-6949 E-mail: yskwon@dau.ac.kr

²Department of Chemistry, Dong-A University, 840 Hadan 2-dong, Saha-gu, Busan 604-714, KOREA.

1. Introduction

Nanoparticulate materials of semiconductors and metals are currently the focus of intense research [1]. The physical properties of such small-scale structures can be tailored for particular applications. For example, their electronic and chemical behavior can be changed simply by controlling the particle size. In recent advances of organic and polymeric materials, dendritic macromolecules, called 'dendrimer', have attracted great interest [2]. Dendrimer can be made with high regularity and controlled molecular weight [3]. Dendrimers, also termed "starburst polymers" process a highly branched molecular topology and physical properties that are determined by their globular and spherical shape. A new class of macromolecules polymer, dendrimers, have a potential ability such as catalysts, drug delivery and chemical sensors and so on [4].

A reliable and long way established method for producing ordered molecular thin films is the Langmuir-Blodgett (LB) technique [5]. The LB technique is a room temperature deposition process that may be used to deposit monolayer and multilayer films of organic materials. Furthermore, this method permits the manipulation of organic molecules in the nanometer scale, thereby allowing intriguing superlattice architectures to be assembled [6].

In this study, we synthesized silsesquioxane dendrimers (G3-9Ph) for fabricating LB film which was expected to have networked structures. The monolayer was deposited onto highly oriented pyrolytic graphite (HOPG) substrate by Y-type deposition of LB technique. The morphologies of the G3-9Ph LB film was observed by tapping mode atomic force microscope (AFM) which can be measured nano-scale analysis of ranging from atom to molecule [7].

2. Experimental

Fig. 1 shows molecular structures of silsesquioxane dendrimers (G3-9Ph) used in this study. The G3-9Ph was prepared with 0.05 mmol/l concentration in chloroform. The two barrier type trough (NIMA, England) was used to investigate the interfacial behavior of G3-9Ph at air/water interface by π -A isotherm. The subphase used distilled water and volume dropped 30 μ l. The monolayer made as compress 5 cycles at barrier speed of 30 mm/s. The monolayer was deposited onto HOPG substrate by Y-type deposition of LB technique at surface pressure 6 mN/m.

The HOPG had done sulphuric acid treatment during 5 min to remove impurities. The substrate was rinsed in ethanol, distilled-water and ozone before the LB film deposition. Then, dipping speed of the substrate was 5 mm/min. The fabricated LB film was dried for a day. Before the experiment, we confirmed that current passed through the LB film using multimeter. We used SPM (Digital Instruments, USA) to measure the surface morphology of G3-9Ph. To obtain morphology data, tapping mode AFM were performed in atmosphere at room temperature.

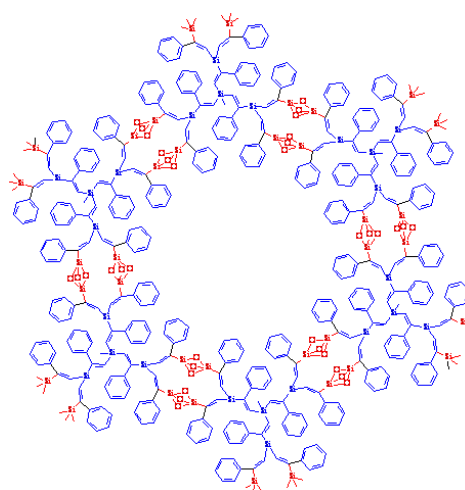


Fig. 1 Molecular structure of G3-9Ph.

3. Results and discussion

Fig. 2 shows an investigation of the monolayer behavior by π -A isotherms at the air-water interface. In general, π -A isotherm is classified by the gas, the liquid, the solid state and the collapse. The π -A isotherm displayed surface pressure of this LB film from liquid to solid state ranged between 5 and 8 mN/m. The slope of π -A isotherm became sharper in the solid state. So, we found that the molecular area of G3-9Ph decreased as the experiment progressed. Therefore, we were able to suppose that the molecule combination was harder at the solid state at π -A isotherm. There does not appear to be a collapse point in the 5 cycles π -A isotherms. The monolayer was deposited onto HOPG substrates by Y-type deposition of LB technique at surface pressure 6 mN/m.

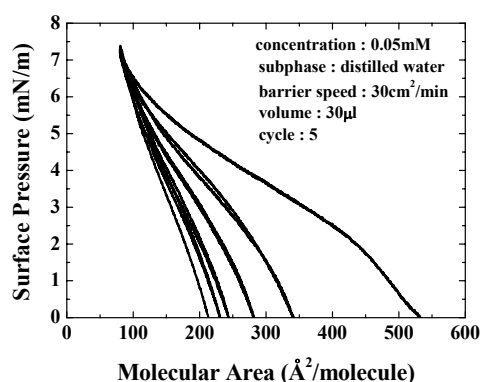


Fig. 2 π -A isotherms of G3-9Ph.

We observed the morphologies of G3-9Ph LB film by SPM. The G3-9Ph LB film was uniformed the networked structure because of combination between molecule and molecule. Therefore, we investigated the bulk morphology of the G3-9Ph LB film. Fig. 3 shows the morphology and section analysis of G3-9Ph LB film on HOPG by AFM at scan size of 1 μm and 500 nm, respectively. The morphology of scan size 500nm was magnified the portion of 1 μm morphology. The morphology shows that molecules deposited uniform which was verified by section analysis of the morphology. From the result, we confirmed that the G3-9Ph deposited to a thickness of 2.1 ~ 2.5 nm on HOPG. Also, the surface vertical distance of deposited G3-9Ph was about 0.4 nm. The roughness of LB film at 1 μm and 500 nm was about 1.001 nm and 0.599 nm, respectively. We confirmed the morphology of the G3-9Ph LB film.

4. Conclusion

In this paper, we investigated the morphology of G3-9Ph LB film. According to the π -A isotherm, the combination of molecules strengthens with repeating of compression and expansion. We attempted to fabricate a stable LB film of G3-9Ph in solid state. Using AFM, we confirmed that the thickness of the LB film and the surface vertical distance of deposited G3-9Ph were nearly regular. We also are to confirm the networked structure by STM images under 20 nm size. This study will become the basis which is able to apply molecular electronic device to measure in nano-scale.

References

- [1] S. Paul, C. Pearson, A. Molloy, M. A. Cousins, M. Green, S. Kolliopoulou, P. Dimitrakis, P. Normand, D. Tsoukalas, M. C. Petty; *Nano Lett.* **3** (2003) 533.
- [2] J. J. Apperloo, R. A. J. Janssen, L. Groenendaal, J. M. J. Fréchet; *J. Am. Chem. Soc.* **122** (2000) 7042.
- [3] L. L. Miller, R. G. Duan, D. C. Tully, D. A. Tomalia; *J. Am. Chem. Soc.* **119** (1997) 1005.
- [4] A. P. H. J. Schenning, C. Elissen-Roman, J.-W. Weener, M. W. P. L. Baars, S. J. van der Gaast, E. W. Meijer; *J. Am. Chem. Soc.* **120** (1998) 8199.
- [5] S. B. Jung, S.-Y. Yoo, J.-C. Park and Y.-S. Kwon; *J. Kor. Phys. Soc.* **37** (2000) 378.
- [6] M. C. Petty, *Langmuir-Blodgett Films*; Cambridge University Press: Cambridge, 1996.
- [7] N.-S. Lee, W.-S. Choi, H.-K. Shin, D.-J. Qian, Y.-S. Kwon; *Jpn. J. Appl. Phys.* **47** (2008) 1173.

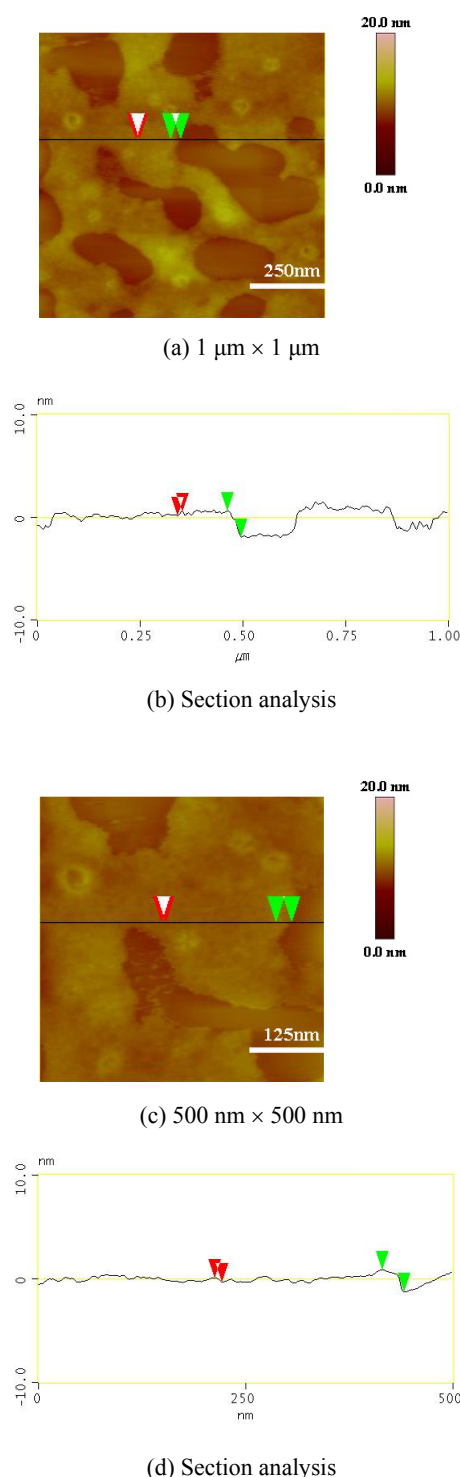


Fig. 3 AFM images of G3-9Ph.